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Possible Uses of VAS Data for Weather Forecasting at the Pacific Weather Centre

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INTRODUCTION

Before 1980, the sensing system aboard the GOES has been the Visible and Infrared Spin Scan Radiometer (VISSR). This radiometer had eight visible channel detectors and two redundant infrared ones.

Since 1980, GOES-4, 5, and 6 were launched with a new sensing system. This new instrument is called the VISSR Atmospheric Sounder (VAS) and will be carried on all future GOES. The VAS has a radiometer possessing the standard eight visible channel detectors plus six thermal detectors that detect IR radiation in 12 spectral bands including 11.2 um and 6.7 um. The 12 IR channels include two IR window channels, three water vapour channels, and seven thermal (CO_2 absorption) channels.

At present, the Pacific Weather Centre is not equipped to receive the proposed data stream (circa 1986) which will contain the extra information.

TWO INFRARED WINDOW CHANNELS - 11.2 um (available) and 3.9 um

The 3.9 um radiances are influenced slightly by the tail region of the solar radiation spectrum. However, its blackbody radiating temperature estimates are more accurate than the standard 11.2 um data because of the lesser amount of attenuation from low level water vapour. Use of the 3.9 um data calibrated to the surface temperature spectrum will give better nighttime estimates of the surface condition.

This data will support the many PWC programs that require surface temperature estimates. Included are the sea surface temperatures, frost forecasts, ground temperatures, stability indicies, fog forecasts, etc. The "sharper" images from the 3.9 um channel should produce a "clearer" picture of the clouds as well as the surface condition. Sharper imagery provides more feature definition and easier interpretation.

THREE WATER VAPOUR CHANNELS - 12.7 um, 7.2 um and 6.7 um (available)

Only 6.7 um imagery is currently available at the Pacific Weather Centre. This data is valid near the 400 mb level. The other channel data, although similar in appearance, is valid at different levels of the atmosphere.

The imagery has become essential in forecast production for the following reasons;

a) Synoptic scale features such as jet streams, deformation zones, low pressure centres, and vorticity maxima are readily identified where mid and high level clouds are not present. Often, some circulation features are not evident in the other imagery.

b) Rapid changes from meridional to zonal flow and vice-versa are indicated in the water vapour patterns before the change is manifested in the cloud pattern detected by the 11.2 um and visible imagery. This earlier detection increases the lead time available to a forecaster when deciding the trend of his forecast. This lead time is critical when weather patterns are changing rapidly.

c) The use of water vapour data at regular time intervals helps to define areas of strong positive or negative vertical velocity (An observation confirmed by Stout et al, 1984). These changes are often preludes to severe weather events, i.e. heavy precipitation, rapid cyclone developments, acceleration of fronts, etc.

d) The water vapour image locates the tropical and/or extra-tropical source of moisture. This allows an estimate to be made as to the amount of water vapour and the subsequent amount of possible precipitation.

SEVEN THERMAL CHANNELS

The seven thermal channels 1 to 6 and 11 sense radiation at 14.7 um, 14.5 um, 14.2 um, 14.0 um, 13.3 um, 4.5 um, and 4.4 um respectively. Each of the seven thermal channels detect radiances that in the absence of clouds are proportional to a weighted average temperature for a particular atmospheric layer. In other words, they depict thermal patterns corresponding to tropospheric temperature or geopotential thickness.

Image Combinations

The utility of the VAS imagery will not likely be apparent when the images are used singularly as when they are compared, combined, or superimposed in some manner (Zehr & Green, 1984). The PWC satellite workstation allows the production of false colour images. These images are easily created by assigning one of the three primary colours (red, green, and blue) to different images. This highlights image differences and similarities while retaining all of the features of the original data.

The most logical procedure in exploiting this powerful technique is to use data with some similar characteristics in order to study the differences. Possible examples of this "extra dimensional imagery" is some combination of the window channels (3.9 um IR, 11.2 um IR, and visible). The 3.9 um window channel gives some information similar to the visible and some other information similar to the 11.2 um infrared. These images in false colour should let the forecaster better delineate cloud and surface features, precipitation areas, amount of cloud cover, and cloud types (i.e. heavy convection), etc.

Other sets of images that could be natural combinations are the three water vapour images and any three of the thermal channels. Use of the former will enable forecasters to determine low and high level moisture boundaries, potential instability, changes in frontal slopes, etc. The latter should portray information related to the three dimensional thermal structure of the atmosphere.

When investigating the uses of VAS satellite data in weather analysis and prediction, Peterson et al (1982) concluded that: "VAS imagery depicts mesoscale moisture patterns for the upper and lower troposphere which provide structure that cannot be fully resolved (nor verified) with the conventional radiosonde data base". This observation was made while working on case studies over areas with an adequate radiosonde network. Over the data void Pacific and data sparse mountainous regions, the VAS image data may ultimately be the only source of upper air information available to support the Day-1 forecast programs.

METEOROLOGICAL PARAMETERS

The radiance data from the spectral bands may be used to generate quantitative meteorological parameters (retrieval profiles will be treated as a special case in the next section). Data from one or two of the bands may be treated with simple algorithms that produce useful information.

One documented example is the "split window technique" (Chesters et al, 1983) for computing precipitable water in the lower levels of the troposphere. The motivation for development of this method was the important role of low-level water vapour to the development of deep convection. The further procedure of overlaying the 6.7 micron channel over the "split window" low level moisture field gives regions of potential instability within which intense convection rapidly develops (Peterson et al, 1982).

More accurate cloud top height assignments (Hayden et al, 1984) will be possible with estimates from several spectral bands. Motion vectors generated from the cloud top positions will give better wind flow information. This information is especially important for the aviation forecast program.

The Pacific Weather Centre is already developing a technique for estimating precipitation areas based on satellite data (Neil, L., 1984). This technique can be improved with better assessment of the vertical distribution of moisture available from the VAS data.

As the VAS data becomes available, other similar techniques will be developed.

VAS SOUNDINGS

Improvements in the Day-1 forecasts can come only with more quantitative information in the following areas:

a) in regional mesoscale meteorological situations
b) over data sparse mountain regions
c) in the synoptic scale over data void areas such as the Pacific Ocean.

Retrieval profiles from the VAS can assist greatly in satisfying the above requirements.

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Table 1

Reprinted from Zehr & Green, 1984

Spectral	Central Wavelength ($um = 10^{-6}m$)	Absorbing Constituent	Peak Level (mb)	Representative Thickness (mb)	Surface or Cloud Emission Effect
1	14.7	CO_2	40	150-10	usually none
2	14.5	CO_2	70	200-30	nothing below 500 mb
3	14.2	CO_2	300	500-10	nothing below 800 mb
4	14.0	CO_2	450	800-300	weak
5	13.3	CO_2	950	SFC-500	moderate
6	4.5	CO_2	850	SFC-500	moderate
7	12.7	H_2O	surface	SFC-700	strong
8	11.2	window	surface	---	strong
9	7.2	H_2O	600	800-400	weak at surface
10	6.7	H_2O	450	700-250	nothing at surface
11	4.4	CO_2	500	800-100	weak
12	3.9	window	surface	---	strong

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